MEMORANDUM

TO: Gale Rankin
Project Manager
Environmental Planning Unit

FROM: James L. Nelson, C.E.G., C.H.G.

SUBJECT: Hydrogeologic Evaluation of Zone 1
Carnadero Preserve
Proposed Wetlands
Southern Santa Clara County

DATE: December 13, 2004

cc: N. Nguyen, D. Titus, T. Trinh, Y. Lee, M. Garvin, Y. Lee, R.L. Volpe, J. Nelson, records management, file

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1.0 INTRODUCTION AND BACKGROUND INFORMATION

This memorandum summarizes the results of our hydrogeologic evaluation of Zone 1 of the Carnadero Preserve, which is a proposed wetlands project in southern Santa Clara County, California. The project site location is shown on the Vicinity Map (Figure 1).

The project involves design and construction of a wetland and riparian habitat near the confluence of Uvas-Carnadero Creek and Pajaro River and the minor mountainous streams known as Tar Creek and Tick Creek. The Carnadero Preserve property consists of ~480 acres of farm land. The current project will involve constructing a wetland area on ~39 acres of a roughly triangular portion of the property designated as Zone 1 (hereafter termed "project site"), which is situated at the southern end of the 480-acre property (pink cross hatch area on Figures 1 through 5).

Actual wetland construction will consist of several options which are not addressed in this memo. It is anticipated that the project site will become an established wetland with numerous potential water sources such as 1) ponded surface overland flows, 2) storm water overbank flow from adjacent creeks and rivers, and 3) possible intercepted shallow groundwater flow. This memo deals solely with item 3, while items 1 and 2 were addressed at the project site by Philip Williams & Associates in their 2003 report (see below).

It is our understanding from discussions with you that Mr. Kent Aue of the California Department of Fish and Game expressed concerns that the site geology may not be adequately characterized and that unfavorable conditions may provide a fatal flaw to site development. Mr. Aue specifically requested that a district geologist review the existing geologic and hydrogeologic data to provide appropriate input to the project.

2.0 Summary of Findings

The results of our hydrogeologic evaluation indicate that important factors that control the shallow hydrogeology of the project site include the relative position of the project site on a slightly elevated upland area and the underlying geology. Our analysis of limited shallow groundwater data indicates alluvial fan sediments beneath the project site appear to be a major groundwater conveying system for the discharge of surface water and shallow groundwater flowing eastward from the Santa Cruz Mountains. This discharged flow appears to be a potentially important source of water for the proposed wetlands on the project site.

Based on groundwater data from 2003 to 2004, it appears that yearlong seasonal piezometric surface elevations beneath the subject site are similar with slightly higher elevations (3 feet to 5 feet) during winter/spring compared to summer/fall conditions. The shallow groundwater gradient and flow direction is consistently from the mountainous areas in the west through the project site to the valley floor in the east. This is evident by the presence of higher groundwater elevations in open well P-4 just west of the project site and lower conditions in open wells to the east (P-1, P-2, and P-5). This trend is consistent over the entire upland area including the project site indicating that shallow groundwater is flowing from the mountainous source (Santa Cruz Mountains) in the west through the older alluvial fan deposits to the east-northeast throughout the year.

3.0 PURPOSE OF HYDROGEOLOGIC EVALUATION

The objectives of our evaluation are to address potential hydrogeologic constraints at the Carnadero Preserve site that could affect the proposed wetlands mitigation and to evaluate overall geologic and hydrogeologic suitability of the project.

4.0 INFORMATION PROVIDED

We were provided with the following:

1) A copy of a hydrologic and hydraulic evaluation report of the project site prepared by Philip Williams & Associates, Ltd. (PWA) dated August 11, 2003, titled "*Lower Uvas -Carnadero Creek Property Wetland and Riparian Habitat Improvement Opportunities: Hydrologic and Hydraulic Evaluation*."

2) An electronic Excel file that summarizes shallow groundwater piezometric levels from site open wells from March 2003 to September 2004 titled "*Piezos_Oct_to_Sept.xls*"

3) An electronic AutoCAD file of site topography from district server address: *g:\gis\projects\621841\2003_110\cad\e-topo-dxf.*

4) Copies of boring logs of site open wells logged and prepared by Shaw Environmental & Infrastructure, Inc. dated March 3 and 4, 2003

5) A copy of Santa Clara Valley Water District Figure 5., which is a map that shows the

location of twelve existing open well piezometers and various land area categories of the proposed wetland titled "*Rough-mapped Typical Surface Water Locations January April 2003**", scale 1"= 684'

6) A copy of Santa Clara Valley Water District Sheet 2 of 3, which is a map that shows locations of proposed borings and open well piezometers titled "*Parajo* (sp) *Basin Mitigation Wetland Potential Wetlands Site 1*", scale 1" = 100'

5.0 SCOPE OF WORK

For our hydrogeologic evaluation of the project site, we performed the following work:

1. Researched available geologic and hydrogeologic information.
2. Evaluated collected shallowest groundwater data from 12 onsite open well piezometers.
3. Performed a graphic analysis of piezometric elevation surfaces from the existing open well piezometers.
4. Generally assessed shallowest groundwater conditions for the proposed wetland.
5. Prepared this memorandum of findings.

6.0 PREVIOUS WORK

On March 3 and 4, 2003, twelve borings were drilled at the locations shown on Figures 2 through 5 and converted to open well piezometers under the direction of Shaw Environmental & Infrastructure, Inc. (SE&II). According to SE&II boring logs, all borings were drilled with 8-inch diameter hollow stem augers, drilled to a depth of 10 feet, and constructed with 2-inch diameter SCH 40 PVC well casing to the total depth of each boring. Well casing slot size was 0.020" and 2/12 sand was placed as a filter pack around the lower 5-foot-long slotted portion of each well. A bentonite seal and neat cement grout was placed in the upper 5-foot-long blank portion of each well.

District personnel have been collecting shallow groundwater data from the12 onsite open wells numbered P-1 through P-9, and P-12 through P-14 from March 2003 through the present. For some reason there are no wells numbered P-10 and P-11. District personnel also mapped areas of ponded water in 2003 (personal communication, G. Rankin, November 2004).

Philip Williams & Associates, Ltd (PWA, 2003) completed a hydrologic and hydraulic evaluation of the project site (Zone 1) along with Zones 2 and 3. The following are PWA findings and conclusions (using their numbers) pertinent to this hydrogeologic evaluation:

> *4. Groundwater monitoring on site in March, April and May indicated that the groundwater levels (excluding well 4) averaged 1.9 + 0.8 ft below the surface across site, during precipitation conditions that were 13% below historical average annual accumulations.*
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> *6. Estimates of surface runoff indicated that local rainfall could provide an average of approximately 14 acre-ft/month in Zone 1…*

> *7. Hydraulic modeling on the Uvas-Carnadero indicated that, on average, floodwaters will likely overtop the channel levees along the project reach every 3 to 4 years and flooding from backwater effects on the Pajaro may inundate up to 90% of the site during the 10-year flood event.*
>
> *8. Overbank flow to the floodplain along the Uvas-Carnadero could be increased, on average, to 3-year events by lowering the western levee to adjacent ground elevations along the project reach.*
>
> *11. Groundwater supplies, augmented by local runoff, appears adequate to support seasonal wetlands in Zones 1-3 on the project site.*

7.0 GEOLOGIC AND HYDROGEOLOGIC FINDINGS

7.1 Surface Conditions

The project site is situated directly east of the eastern foothills of the Santa Cruz Mountains, about 2 miles south-southwest of downtown Gilroy, California (Figure 1). The project site is bounded predominantly by agricultural and ranch lands. Highway 101 defines the western and southwestern boundaries, Tick and Gavilan Creeks define the northern boundary, Uvas-Carnadero Creek defines the eastern boundary, and Pajaro River defines the southern boundary of the project site.

Lands northeast and east of the project site consist of relatively level valley floor or “low lands” that possess minor slope gradients of less than 0.5 degree. The project site includes a generally northwest-southeast-trending strip of land (hereafter termed “upland” area) approximately 1½ miles long and up to ~1/3 mile wide that is situated on gently sloping, east-northeast- to east-southeast-facing ground. The uplands are elevated slightly (up to about 20 feet) above the valley floor and flank the eastern foothills of the Santa Cruz Mountains. This strip of upland area marks the boundary between valley floor sediments of Santa Clara Valley deposited by relatively larger streams (Pajaro River and Uvas-Carnadero Creek) and bedrock slopes of the Santa Cruz Mountains to the west. A detailed explanation for the formation of the upland area and underlying alluvial fan sediments is presented in section *7.2.2 Development and Character of Alluvial Fan Deposits.*

The upland area north of the project site possesses gentle gradients of ~2 degrees to the east-northeast, while gradients on the project site are ~1 degree east-southeast.

7.2 Site and Regional Geology

The geology of the project site and vicinity are shown on the following published maps:

Allen (1946); California Division of Mines
Dibblee and Brabb (1978); U.S. Geological Survey (U.S.G.S.)
Helley and others (1979); U.S.G.S.
Ellen and Wentworth (1995); U.S.G.S.

Rogers and Williams (1974); California Division of Mines and Geology (recently renamed "California Geological Survey")

A significant geologic aspect of the upland area that directly controls the shallow groundwater hydrogeology beneath the project site is the fact it is underlain by older alluvial fan (stream) sediments that began as eroded bedrock materials and were eventually deposited at the intersection of the mountain slopes and valley floor by the minor mountainous streams of Tick Creek and Tar Creek. A detailed explanation for the formation of alluvial fans is presented in section *7.2.2 Development and Character of Alluvial Fan Deposits.*

On all published and unpublished maps the project site and vicinity are shown underlain predominantly by alluvium, older alluvium, or terrace gravels ranging in age from ~10,000 to 35,000 years old, with lesser amounts of recent (modern) alluvium deposited along active stream channels. We infer that the older alluvium is underlain at depth (~0 to 50 feet) by Pliocene sandstone bedrock because these rocks crop out in the mountains immediately to the west.

Another significant aspect that contributes to the overall hydrogeology of the project site is its general location at the intersection of Santa Clara Valley at its southwestern corner and the Pajaro River Gap (also known as Chittenden Gap). The gap is a major bedrock constriction of Pajaro River as it passes westward through the Santa Cruz Mountains before entering the Pacific Ocean. Just south of the project site the Pajaro River goes from flowing unrestrained along the valley floor to being confined by bedrock slopes. Some geologists have speculated that Pajaro River flowed westward prior to uplift of the Santa Cruz Mountains. Pajaro Gap appears to have formed by the down cutting action of Pajaro River as the Santa Cruz Mountains formed. By virtue of project site's location near the constriction of Pajaro Gap, where relatively thick river sediments to the north meet a bedock channel to the south, surface and subsurface waters are naturally funneled toward the project site. In their report PWA (2003) provided the following significant observation regarding the overall suitability of the site: *"the Lower Uvas-Carnadero property has excellent potential for above average surface and groundwater supplies due to its proximity to the topographic constriction of Chittenden Gap and the resulting backwater affects on surface and groundwater drainage."*

7.2.1 Geologic Units

We compiled and modified information from published geologic maps to produce a geologic site map that shows three separate alluvium units based on relative age (younger versus older) and one bedrock unit as shown as Figures 2 through 6. Figure 6 is a geologic cross section that shows inferred relationships between various geologic units.

7.2.1a Surficial Units

Modern stream channel sediments (alluvium or Qal) are mapped adjacent to, and within, the modern stream channels of Uvas-Carnadero Creek and Pajaro River along the east-northeast boundary, and the mountain stream channels of Tick and Tar Creek along the west-northwest boundary of the project site. Slightly older alluvial valley fill sediments (Qvf) are mapped in a wide area north and east of the project site i.e. land to the north of Tick Creek and east of

Pajaro River. Older alluvial fan sediments (Qoa) underlies the minor upland area of the project site, as mentioned in section *7.1 Surface Conditions.*

Modern (Holocene to Recent) alluvium (Qal) consists of unconsolidated fine-grained silts and clays, and coarse-grained sands and gravels deposited along the modern channels of Uvas-Carnadero Creek, Pajaro River, and Tick Creek and Tar Creek as shown as lighted shaded areas on Figures 2 through 5.

Holocene alluvial valley fill (Qvf) consists of unconsolidated clays, silts, sands, and gravels deposited as channel and overbank units.

Older Quaternary alluvial fan sediments (Qoa) consists of unconsolidated to semi-consolidated fine-grained silts and clays and coarse-grained sands and gravel that underlie thin upper soil horizons and overlie bedrock beneath the project site (Figures 2 through 6). These sediments were deposited by streams several thousand years ago and have subsequently been slightly uplifted above the valley floor by tectonic movements of the Santa Cruz Mountains along the Sargent fault (see Section *7.4 Sargent Fault and its Potential Impact on Site Groundwater Conditions*).

7.2.1b Bedrock Unit

As mentioned above, the likely bedrock beneath the older alluvium at the project site is mapped by Dibblee and Brabb (1978) as underlain by an unnamed Pliocene sandstone unit (Tus). Allen (1946), Rogers and Williams (1974), and Ellen and Wentworth (1995) mapped this bedrock as the Purisima Formation.

Ellen and Wentworth (1995) provide a general description of the Purisima Formation near Pajaro River at the southern end of the Santa Cruz Mountains. In the vicinity of the project site the Purisima Formation consists of about equal proportions of 1) coarser grained sandstones and conglomerates, and 2) fine-grained clayey sandstone, mudstone and shale.

7.2.2 Development and Character of Alluvial Fan Deposits

During and after prolonged winter and spring storms sediment load is eroded from upstream mountainous slopes, which is then carried eastward by flowing waters through the stream channels of Tick and Tar Creek from the Santa Cruz Mountains. The upstream mountain creek channels are able to transport eroded sediment load through their channels due the energy provided by the relatively steeper mountain gradients and confined channel flow. This energy decreases significantly, however, when the stream channels intersect the valley floor due to a marked decrease in gradient and lack of a confined channel. At this point, the stream can no longer carry the eroded sediment and the load is deposited onto the valley floor to the east and at the mouth of the mountain creek channels. The progressive buildup of deposited alluvial sediments produces a series of conical, open-fan-shaped ground typical of alluvial fans and the upland area of the project site.

Alluvial fan sediment usually consists of fairly coarse-grained sands and gravels with lesser amounts of finer-grained silts and clay. This appears to be especially true for sediments emanating from Tick and Tar Creeks because the lengths of the stream channels are relatively short and the bedrock is partially composed of sandstone. Short travel distances before deposition means that sediments have less time to be significantly eroded and weathered and are more likely to be coarser grained (sands and gravels). However, because the bedrock partially consists of some clayey sandstone and mudstone, some fine-grained sediments will also likely be deposited in the alluvial fan.

The alluvial fan sediments of the upland area overlap the valley floor sediments of the lowland area at the junction between the toe of the fan and the valley floor. Two depositional processes result in the alternating or cyclic deposition of alluvial fan sediments (material eroded from bedrock of the Santa Cruz Mountains) and river sediments of the valley floor. Once alluvial fan sediments from Tick and Tar Creeks are deposited onto the valley floor they are periodically inundated by flood waters from major stream systems of Uvas-Carnadero Creek and Pajaro River. This results in alternating deposits of valley fill overbank deposits (fine-grained silts and clays) and predominantly coarse-grained (sands and gravels) of the alluvial fan sediments. Consequently, the toe of the fan in section view consists of thin interlocking or overlapping wed-shaped layers (interfingering) of alluvial fan sediments and valley fill sediments (see Figure 6). As shallow groundwater flows through the alluvial fan and encounters the fan toe the shallow groundwater will tend to follow the more permeable coarser alluvial fan layers and become perched on the relatively impermeable finer valley fill layers. As discussed in section *9.0 Discussion of Project Site Surface and Groundwater Conditions*, some of the ponded surface water and artesian conditions observed in the winter of 2003 at the toe of fan may be due to day lighting of shallow groundwater as charged permeable layers encounter the less permeable valley fill sediments.

With time, sediments from Tick and Tar Creeks pile up at the mouth of the creek channels to create an alluvial fan surface that is conical or fan-shape. A series of coalescing fans is the general topographic expression of the upland area shown on the Geologic Site Map (Figures 2 through 5). The successive deposition of sedimentary loads onto the conical surface means that the alluvial fan sediments will generally consist of relatively thin gently to moderately valley-ward (east-northeastward) dipping layers. As discussed in section *9.0 Discussion of Project Site Surface and Groundwater Conditions*, the internal geometry and orientation of the alluvial fan sediments are important because they probably govern the observed shallow groundwater gradient and flow direction.

7.3 Surface Water and Groundwater

Surface drainage over most of the 480-arce property north of the project site is fairly complex, with multiple sources ranging from overland sheet flow and channelized flow through the various established creeks and rivers. Also, natural surface flow has been altered by agricultural activity in the cultivated portions of the site to the north and east, which has created numerous artificial drainage ditches. Overall, it appears that surface water from creeks that historically flowed generally eastward and flooded the valley has been artificially redirected short distances southward so that flow does not adversely affect the agricultural fields of the valley floor. This is evident by a relatively abrupt ~right angle bend in Tick Creek where it passes beneath highway 101. The natural creek channel that probably flowed historically eastward appears to have been redirected southward through an artificial channel.

Surface drainage on the project site consists primarily of eastward to southeastward unchanneled sheet flow across the broad old alluvial fan surface as shown by light blue arrows on Figures 2 through 5. Locally, channelized surface flow occurs within the eastward flowing Tar Creek along the northern boundary of the project site and within the southward flowing Uvas-Carnadero Creek along the eastern boundary. Channelized flow continues southward at the confluence of Uvas-Carnadero Creek and Pajaro River along the southeastern and southern boundary of the project site (blue arrows on Figures 2 through 5). Because predominantly older alluvium appears to underlie most of the project site, much of the precipitation probably readily infiltrates these materials at depth.

Previous mapping by G. Rankin in 2003 shows six areas of ponded surface waters across the 480-acre property (blue areas on Figures 2 through 5). Three minor ponded areas were mapped along the eastern boundary of the project site. A historic U.S.G.S. map from 1915 shows marshy ground about 300 feet north-northwest of Zone 1 along Tick Creek. The marsh coincides with ponded water mapped in 2003.

Seasonal shallow groundwater movement in the region surrounding the project site is likely to be highly complex in the underlying earth materials. The results of our analysis of seasonal shallow groundwater beneath the project site are presented in Section *8.0 Graphic Evaluation of Shallowest Groundwater Conditions.* A discussion of shallow groundwater processes is presented in section *9.0 Discussion of Project Site Surface and Groundwater Conditions.*

7.4 Sargent Fault and its Potential Impact on Site Groundwater Conditions

Published maps show traces of the northwest-southwest-trending Sargent fault northwest of the project site as shown on the Geologic Site Maps (Figures 2 through 5). Two fault traces (dashed lines on Figures 2 through 5) mapped directly northwest of the project site are inferred as running southeastward beneath the site. It should be noted that the northeastern-most fault trace has been mapped as the Castro fault (Dibblee and Brabb, 1978), which is a subsidiary trace of the Sargent fault. The locations of these faults are uncertain because they are concealed (dotted lines) beneath the older alluvial fan sediments. The Sargent is an active thrust fault of the San Andreas fault system, which exhibits predominantly dip-slip movement (as opposed to strike-slip movement typical of the main San Andreas fault trace). Relative movement along the Sargent fault consists of an up-thrown block to the southwest and a down-thrown block to the northeast (see Figure 6).

Long term fault movements typically create pervasively sheared zones in bedrock and soil. These disturbed earth materials readily weather to relatively impermeable clayey soils. Because of their impermeable nature, these soils can be barriers to shallow groundwater movement. Consequently, it is possible that eastward flowing shallow groundwater (with sources to the west) could encounter the Sargent fault-related barrier at depth to produce mounded shallow groundwater conditions west of the fault beneath the project site.

8.0 GRAPHIC EVALUATION OF SHALLOWEST GROUNDWATER CONDITIONS

This section summarizes the findings of a graphic evaluation of shallowest groundwater surfaces based on site open well groundwater piezometric data from March 2003 through

September 2004. Shallow groundwater data were collected from 12 onsite open wells numbered P-1 through P-9, and P-12 through P-14 as shown on Figures 2 through 5. For some reason there are no wells numbered P-10 and P-11.

Open wells P-1 through P-5 are generally situated around the perimeter of the project site, while the remaining 7 open wells are located near the intersection of the upland and lowland areas to the northwest.

Specific methodology consisted of generating contour maps of available open well piezometer data using ***Surfer*** (v.7.0) software program by Golden Software of Golden, Colorado. ***Surfer*** creates contour and gradient maps from 3-dimensional (x-y-z) data using various algorithms. As described in detail below, based on input of selected sets of piezometric data, ***Surfer*** software generated contour maps that were then overlain onto a topographic map of the project site. The ***Surfer*** generated contour maps are plan (two dimensional) views of specific piezometer contours, which are defined below.

8.1 Methodology for Evaluating Seasonal Shallow Groundwater

Surfer generated contour maps shown on Figures 2 through 5 are based on the kriging algorithm using x-y coordinates of the open well piezometers and corresponding shallowest groundwater data defined as the z-direction. As stated above, each generated contour map was overlain on a topographic map of the project site. Two types of z-direction data were used to generate 2 sets of "topographic" maps. One map set (Figures 2 and 3) shows lines of equal elevation (the "topography") of the shallow groundwater surface based on piezometric surface elevation (PSE) data in feet. We calculated piezometric surface elevations in feet (PSE) by subtracting the depth to water from the elevation at ground surface at the top of the corresponding open well. The other map set (Figures 4 and 5) shows lines of equal depth to shallow groundwater in feet. Because planned wetland construction involves creating a lowland area that will hopefully intercept surface waters and groundwater, depth to shallow groundwater is important.

The data used in generating the "topographic" maps is summarized in Table 1.

To depict the seasonal high and low conditions we chose open well piezometer data that was highest (closest to ground surface) during the winter/spring (generally defined as October through June) and data that was lowest (closest to the well bottom) during the summer/fall (generally defined as July through September). The available open well piezometer data was limited and ranged from March 2003 through September 2004. Historic, long term shallow groundwater data was not available. Specifically, the summer/fall piezometric data was from June 2003 through September 2003 and the winter/spring data was predominantly from January and March 2004.

From the available data, seasonal high conditions typically occurred during December through April and seasonal low conditions typically occurred during June through September. Figure 2 and Figure 3 show, respectively, the general piezometric surface elevation (PSE) during winter/spring (high condition) and summer/fall (low condition); while Figure 4 and Figure 5 show, respectively, the depth to shallow groundwater during winter/spring and summer/fall.

Possible minor artesian conditions exist in open wells P-8 and P-9 as indicated by the slightly positive values (0.1 ft and 0.2 ft, respectively) of depth to shallow groundwater during winter/spring conditions. Apparently, the general area of these open wells corresponds to artesian agricultural wells (personal communication, G. Rankin October 2004).

Table 1 - X-Y-Z Values Used in ***Surfer*** Analysis
Open Well Piezometers - Carnadero Preserve
Summer 2003 to Spring 2004

	X-Values	Y-Values	Well information		Z-Values	Z-Values	Z-Values	Z-Values
			surface	bottom	high w/s	low s/f	high w/s	low s/f
Piezo No.	easting	northing	elev. in ft	elev. in ft	PSE ft	PSE ft	below grade ft	below grade ft
P-1	6257118	1796931	130.25	120.25	129.2 Ma04	122.1 Ju03	-1	-8.2
P-2	6256647	1797426	133.93	123.93	133.0 Ma04	125.0 Ju03	-0.9	-9.0
P-3	6256765	1797747	132.66	122.66	132.4 Ma04	123.3 Ju03	-0.3	-9.4
P-4	6255914	1798010	141.85	131.85	135.0 Ma04	132.9 Ju03	-6.8	-9.0
P-5	6256710	1798653	132.52	122.52	129.9 Ja04	123.8 Ju03	-2.6	-8.7
P-6	6256800	1799167	128.93	118.93	128.2 Ma04	123.3 Se03	-0.7	-5.6
P-7	6256612	1799743	129.07	119.07	128.9 Ma04	124.3 Se03	-0.2	-4.8
P-8	6256087	1800457	130.43	120.43	130.5 Ja04	127.2 Jn03	0.1*	-3.2
P-9	6255561	1800328	129.67	119.67	129.9 Ja04	124.0 Au03	0.2*	-5.7
P-12	6254788	1801218	134.17	124.17	132.5 Ma04	124.7 Au03	-1.7	-9.5
P-13	6255079	1801606	135.23	125.23	134.6 Ja04	126.0 Ju03	-0.6	-9.2
P-14	6254408	1801649	136.78	126.78	134.5 Ma04	128.3 Ju03	-2.3	-8.5

Notes:
PSE = Piezometric Surface Elevation
w/s = winter/spring
s/f = summer/fall
* = possible artesian conditions - slightly above ground surface
Winter/Spring Z values: Ja04 = January 2004; Ma04 = March 2004
Summer/Fall Z values: Jn03 = June 2003; Ju03 = July 2003; Au03 = August 2003; Se03 = September 2003

8.2 Findings of Seasonal Shallow Groundwater Evaluation

Figures 2 and 3 show that overall, yearlong seasonal piezometric surface elevations beneath the subject site are similar with slightly higher elevations (3 feet to 5 feet) during winter/spring compared to summer/fall conditions. For the years monitored (2003-2004) the shallow groundwater gradient and flow direction (shown by white arrows in Figure 3 and yellow arrows in Figure 4) is consistently northeastward beneath the project site with higher elevations in open well P-4 and lower conditions in open wells to the east (P-1, P-2, and P-5). This trend is consistent over the entire upland area including the project site indicating that shallow groundwater is flowing from the mountainous source in the west through the older alluvial fan deposits to the east-northeast throughout the year. Our research indicates P-4 may be underlain by shallow bedrock because Pliocene nonmarine sandstone (Tus) was mapped about directly southwest of Zone 1 (Allen, 1946).

During winter/spring shallow groundwater condition depth to shallow groundwater beneath the project site generally ranges from -1 foot to -5 feet (Figure 4). During summer/fall the depth is greater than -9 feet (Figure 5). It appears that the project site would have the potential to intercept shallow groundwater, which would appear to provide an adequate supply for maintaining seasonal wetlands.

9.0 Discussion of Project Site Surface and Groundwater Conditions

The shallow groundwater contours during winter/spring and summer/fall (shown on Figures 3 and 4, respectively) generally reflect the overall geometry of the alluvial fans of the upland area. This relationship is governed by the internal geometry of the alluvial fan sediments which is a series of interfingering, generally east-northeast-dipping sediments that alternate between coarse grained and fine-grained sediments. Shallow groundwater will tend to flow through the alluvial fan sediments and become perched when it encounters the relatively impermeable valley fill sediments at the fan toe.

The 2003 mapped ponded areas in the vicinity of the project site are situated at the toe of the alluvial fan where valley floor (lowlands) sediments (Qvf) overlap alluvial fan (upland) sediments (Qoa). The ponded areas also lie just north of an inferred concealed trace of the Sargent fault which may have created a shallow groundwater barrier. The presence of seasonal ponded water on the project site appears to be favorable for development and establishment of the proposed wetlands.

It appears possible that all the following factors favor the accumulation of surface water and shallow groundwater on the project site. These include 1) change in gradient from sloping ground of the upland to relatively level ground of the lowlands; 2) interfingering of relatively impermeable valley fill sediments with relatively permeable alluvial fan sediments creating local perched conditions, and; 3) the possible presence of a shallow groundwater barrier produced by movement along the Sargent fault. It also appears likely that shallow groundwater from the east may seasonally intersect the ground surface (daylight) during winter/spring to produce surface springs and the artesian conditions in observation and water wells. This process appears to have created artesian groundwater conditions in the vicinity of the ponded areas where shallow groundwater levels ranged from zero (artesian conditions i.e. at or near ground surface) to -1 foot shown in Figure 4.

10.0 CONCLUSIONS

Based on the findings of our hydrogeologic evaluation we provide the following conclusions:

1) From a geologic and hydrogeologic standpoint, due to the presence of numerous surface water and shallow groundwater sources the project site appears highly favorable for the proposed wetlands mitigation.

   We concur with the finding of PWA (2003) that *“the Lower Uvas-Carnadero property has excellent potential for above average surface and groundwater supplies due to its proximity to the topographic constriction of Chittenden Gap and the resulting backwater affects on surface and groundwater drainage.”*

2) Our analysis of limited shallow groundwater data indicates alluvial fan sediments beneath the project site appear to be a major shallow groundwater conveying system for the discharge of surface water and shallow groundwater flowing from the Santa Cruz Mountains. This discharged flow is a potentially important source of water for the

proposed wetlands on the project site.

3) The presence of seasonal ponded water on the project site appears to indicate favorable conditions for developing and establishing the proposed wetlands. Processes that favor the accumulation of surface waters on the project site include 1) annual source of shallow groundwater recharge from Tick and Tar Creeks of the Santa Cruz Mountains; 2) the internal geometry of generally east-northeast dipping alluvial fan deposits that are the primary source of shallow groundwater at the site; 3) the possible presence of fault produced shallow groundwater barriers and impermeable valley fill sediments at the toe of the fan.

4) During winter/spring depth to shallow groundwater beneath the project site generally ranges from -1 foot to -5 feet (Figure 4). During summer/fall the depth is greater than -9 feet (Figure 5). It appears that the project site would have the potential to intercept shallow groundwater, which would appear to provide an adequate supply for maintaining seasonal wetlands.

Report Prepared by:

Original Signed By:

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Attachments:

1) References
2) Figure 1 Vicinity Map
3) Figure 2 Geologic Site Map & Winter/Spring 2004 Piezometric Surface
4) Figure 3 Geologic Site Map & Summer/Fall 2003 Piezometric Surface
5) Figure 4 Geologic Site Map & Winter/Spring 2004 Depth to Groundwater
6) Figure 5 Geologic Site Map & Summer/Fall 2003 Depth to Groundwater
7) Figure 6 Geologic Cross Section

REFERENCES

Allen, J.E., 1946, Geology of the San Juan Bautista Quadrangle, California: California Division of Mines Bulletin 133, 112 p., 2 maps scale 1:62500.

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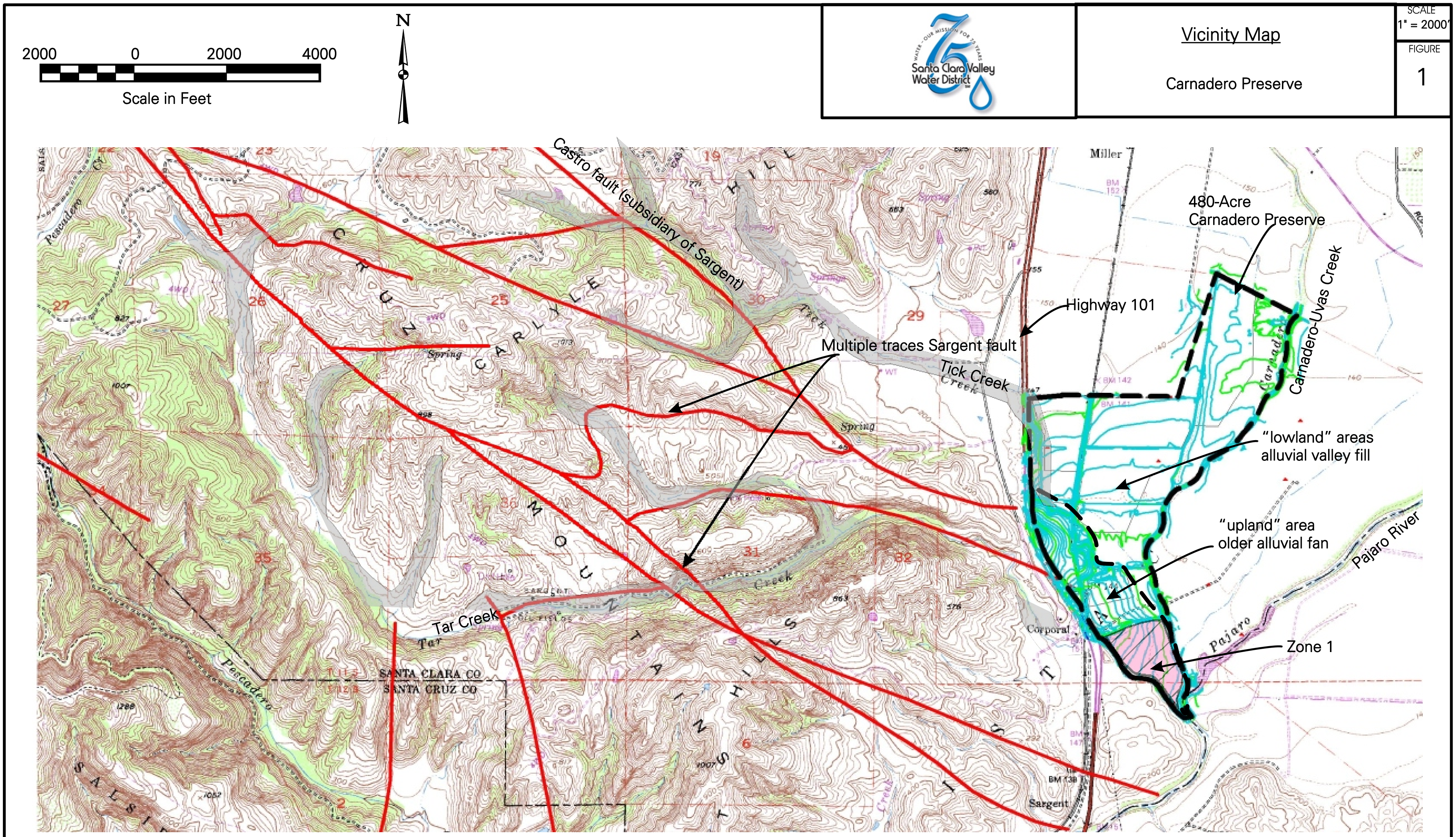
Santa Clara Valley Water District

Vicinity Map

Carnadero Preserve

SCALE
1" = 2000'

FIGURE
1



Note: 1) Base Map: U.S.G.S. 7.5 minute Chittenden, CA quad.
2) file: W:\geology\Pajaro-Uvas\Pajaro-UvasmapF1.cdr

DATE	11/01/04
DESIGN	JLN
DRAWN	JLN
CHECKED	RLV

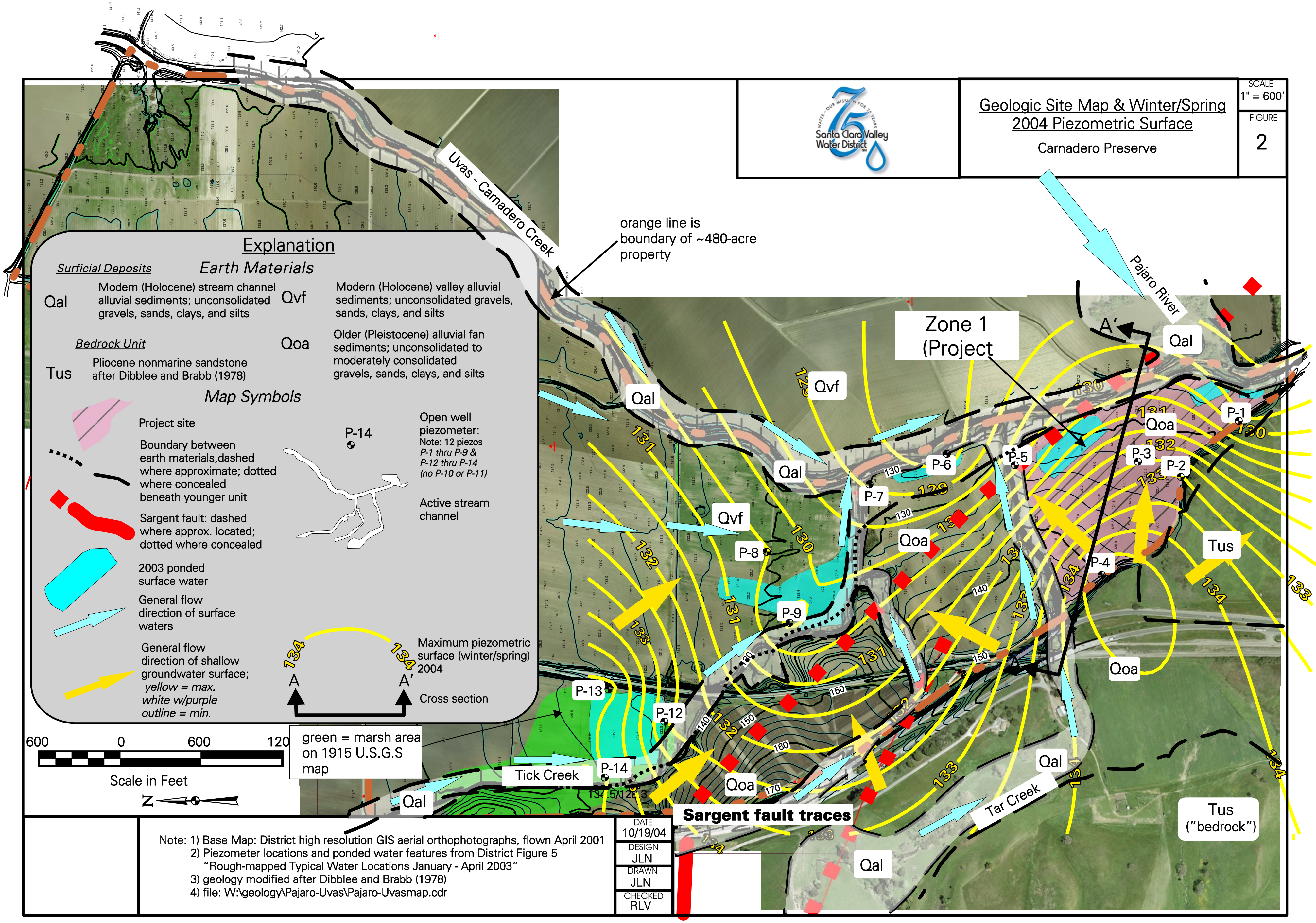
Geologic Site Map & Winter/Spring 2004 Piezometric Surface

Carnadero Preserve

SCALE 1" = 600'

FIGURE 2

Santa Clara Valley Water District



Explanation

Earth Materials

Surficial Deposits

- Qal — Modern (Holocene) stream channel alluvial sediments; unconsolidated gravels, sands, clays, and silts
- Qvf — Modern (Holocene) valley alluvial sediments; unconsolidated gravels, sands, clays, and silts
- Qoa — Older (Pleistocene) alluvial fan sediments; unconsolidated to moderately consolidated gravels, sands, clays, and silts

Bedrock Unit

- Tus — Pliocene nonmarine sandstone after Dibblee and Brabb (1978)

Map Symbols

- Project site
- Boundary between earth materials, dashed where approximate; dotted where concealed beneath younger unit
- Sargent fault: dashed where approx. located; dotted where concealed
- 2003 ponded surface water
- General flow direction of surface waters
- General flow direction of shallow groundwater surface; *yellow = max. white w/purple outline = min.*
- P-14 — Open well piezometer: Note: 12 piezos *P-1 thru P-9 & P-12 thru P-14 (no P-10 or P-11)*
- Active stream channel
- 134 — Maximum piezometric surface (winter/spring) 2004
- A — A' Cross section

600 0 600 120

Scale in Feet

N

Note: 1) Base Map: District high resolution GIS aerial orthophotographs, flown April 2001
2) Piezometer locations and ponded water features from District Figure 5 "Rough-mapped Typical Water Locations January - April 2003"
3) geology modified after Dibblee and Brabb (1978)
4) file: W:\geology\Pajaro-Uvas\Pajaro-Uvasmap.cdr

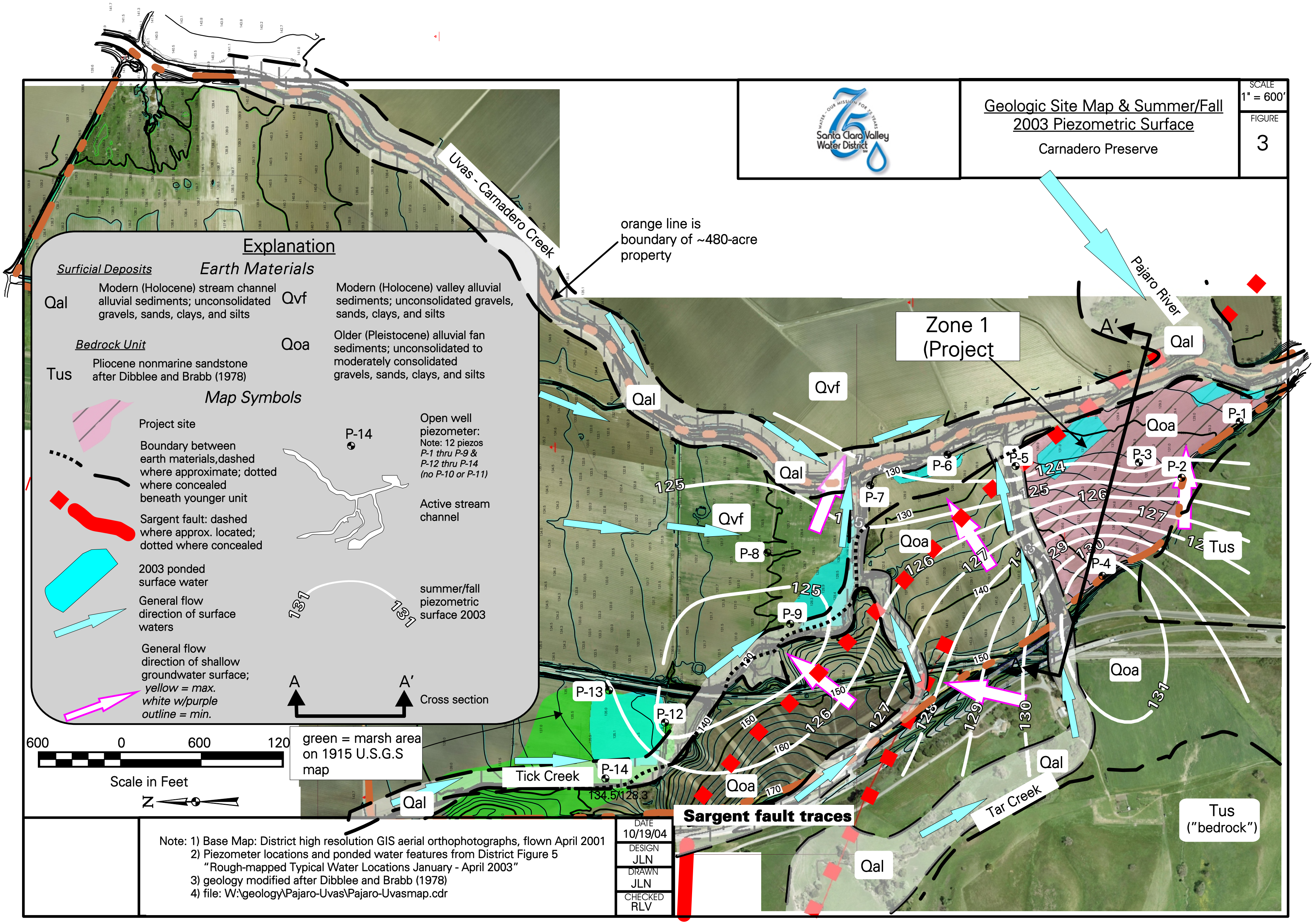
DATE	10/19/04
DESIGN	JLN
DRAWN	JLN
CHECKED	RLV

Geologic Site Map & Summer/Fall 2003 Piezometric Surface

Carnadero Preserve

SCALE
1" = 600'

FIGURE
3



orange line is boundary of ~480-acre property

green = marsh area on 1915 U.S.G.S map

Explanation

Earth Materials

Surficial Deposits

Qal	Modern (Holocene) stream channel alluvial sediments; unconsolidated gravels, sands, clays, and silts
Qvf	Modern (Holocene) valley alluvial sediments; unconsolidated gravels, sands, clays, and silts
Qoa	Older (Pleistocene) alluvial fan sediments; unconsolidated to moderately consolidated gravels, sands, clays, and silts

Bedrock Unit

Tus	Pliocene nonmarine sandstone after Dibblee and Brabb (1978)

Map Symbols

- Project site
- Boundary between earth materials, dashed where approximate; dotted where concealed beneath younger unit
- Sargent fault: dashed where approx. located; dotted where concealed
- 2003 ponded surface water
- General flow direction of surface waters
- General flow direction of shallow groundwater surface; *yellow = max. white w/purple outline = min.*
- P-14 Open well piezometer: Note: 12 piezos *P-1 thru P-9 & P-12 thru P-14 (no P-10 or P-11)*
- Active stream channel
- 131 131 summer/fall piezometric surface 2003
- A A' Cross section

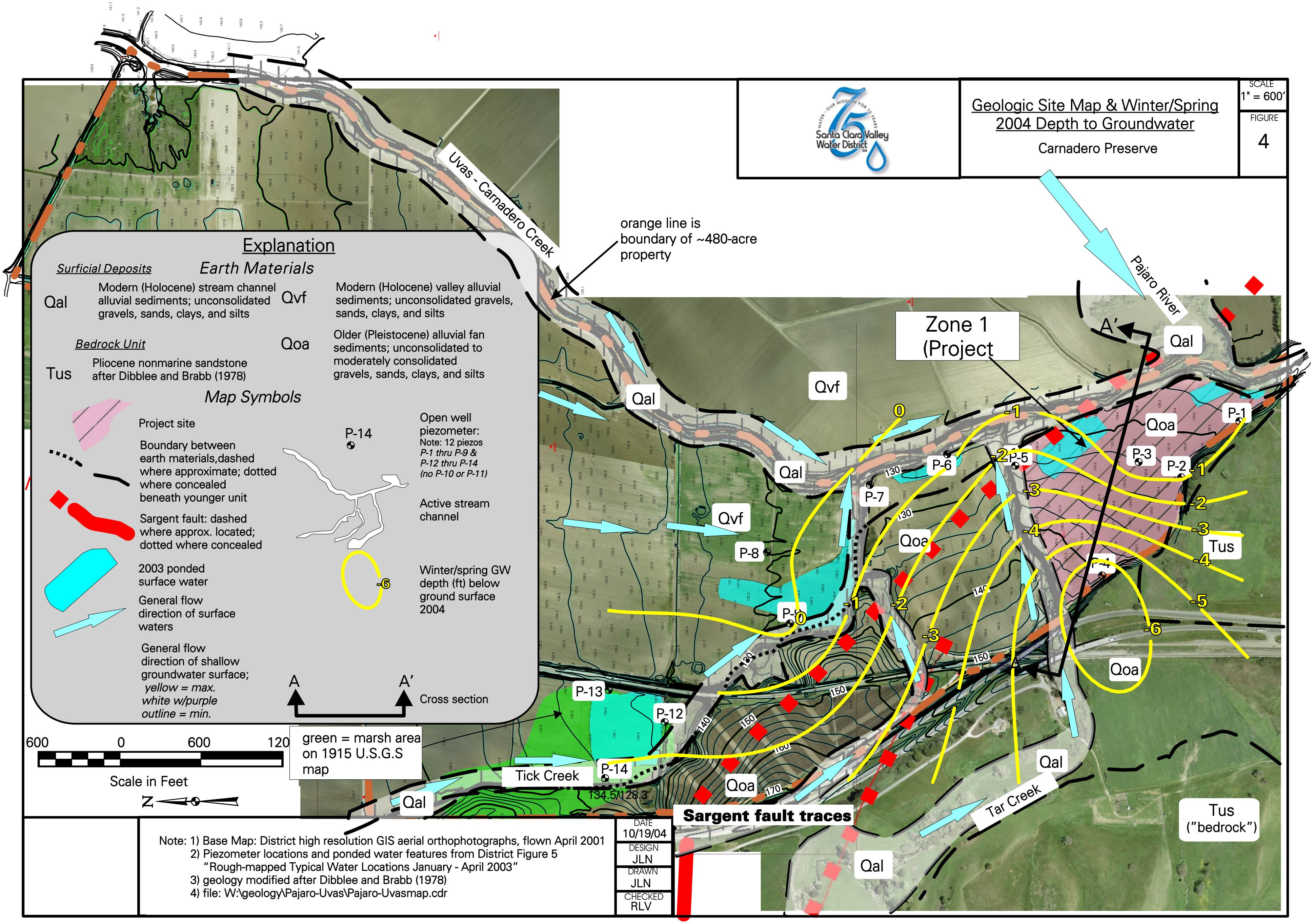
600 0 600 120

Scale in Feet

N

Note: 1) Base Map: District high resolution GIS aerial orthophotographs, flown April 2001
2) Piezometer locations and ponded water features from District Figure 5 "Rough-mapped Typical Water Locations January - April 2003"
3) geology modified after Dibblee and Brabb (1978)
4) file: W:\geology\Pajaro-Uvas\Pajaro-Uvasmap.cdr

DATE	10/19/04
DESIGN	JLN
DRAWN	JLN
CHECKED	RLV



Uvas - Carnadero Creek
orange line is boundary of ~480-acre property
Pajaro River
Zone 1 (Project
Qal
Qvf
Qoa
Tus
Tus ("bedrock")
P-1
P-2
P-3
P-4
P-5
P-6
P-7
P-8
P-9
P-12
P-13
P-14
0
-1
-2
-3
-4
-5
-6
130
140
150
160
170
134.5/128.3
A'
Tick Creek
Tar Creek
Sargent fault traces
green = marsh area on 1915 U.S.G.S map
Explanation
Earth Materials
Surficial Deposits
Qal Modern (Holocene) stream channel alluvial sediments; unconsolidated gravels, sands, clays, and silts
Qvf Modern (Holocene) valley alluvial sediments; unconsolidated gravels, sands, clays, and silts
Qoa Older (Pleistocene) alluvial fan sediments; unconsolidated to moderately consolidated gravels, sands, clays, and silts
Bedrock Unit
Tus Pliocene nonmarine sandstone after Dibblee and Brabb (1978)
Map Symbols
Project site
Boundary between earth materials,dashed where approximate; dotted where concealed beneath younger unit
Sargent fault: dashed where approx. located; dotted where concealed
2003 ponded surface water
General flow direction of surface waters
General flow direction of shallow groundwater surface; yellow = max. white w/purple outline = min.
P-14 Open well piezometer: Note: 12 piezos P-1 thru P-9 & P-12 thru P-14 (no P-10 or P-11)
Active stream channel
-6 Winter/spring GW depth (ft) below ground surface 2004
A A' Cross section
600 0 600 120
Scale in Feet
N

Santa Clara Valley Water District

Geologic Site Map & Winter/Spring 2004 Depth to Groundwater

Carnadero Preserve

SCALE	FIGURE
1" = 600'	4

DATE	DESIGN	DRAWN	CHECKED
10/19/04	JLN	JLN	RLV

Note: 1) Base Map: District high resolution GIS aerial orthophotographs, flown April 2001
2) Piezometer locations and ponded water features from District Figure 5 "Rough-mapped Typical Water Locations January - April 2003"
3) geology modified after Dibblee and Brabb (1978)
4) file: W:\geology\Pajaro-Uvas\Pajaro-Uvasmap.cdr

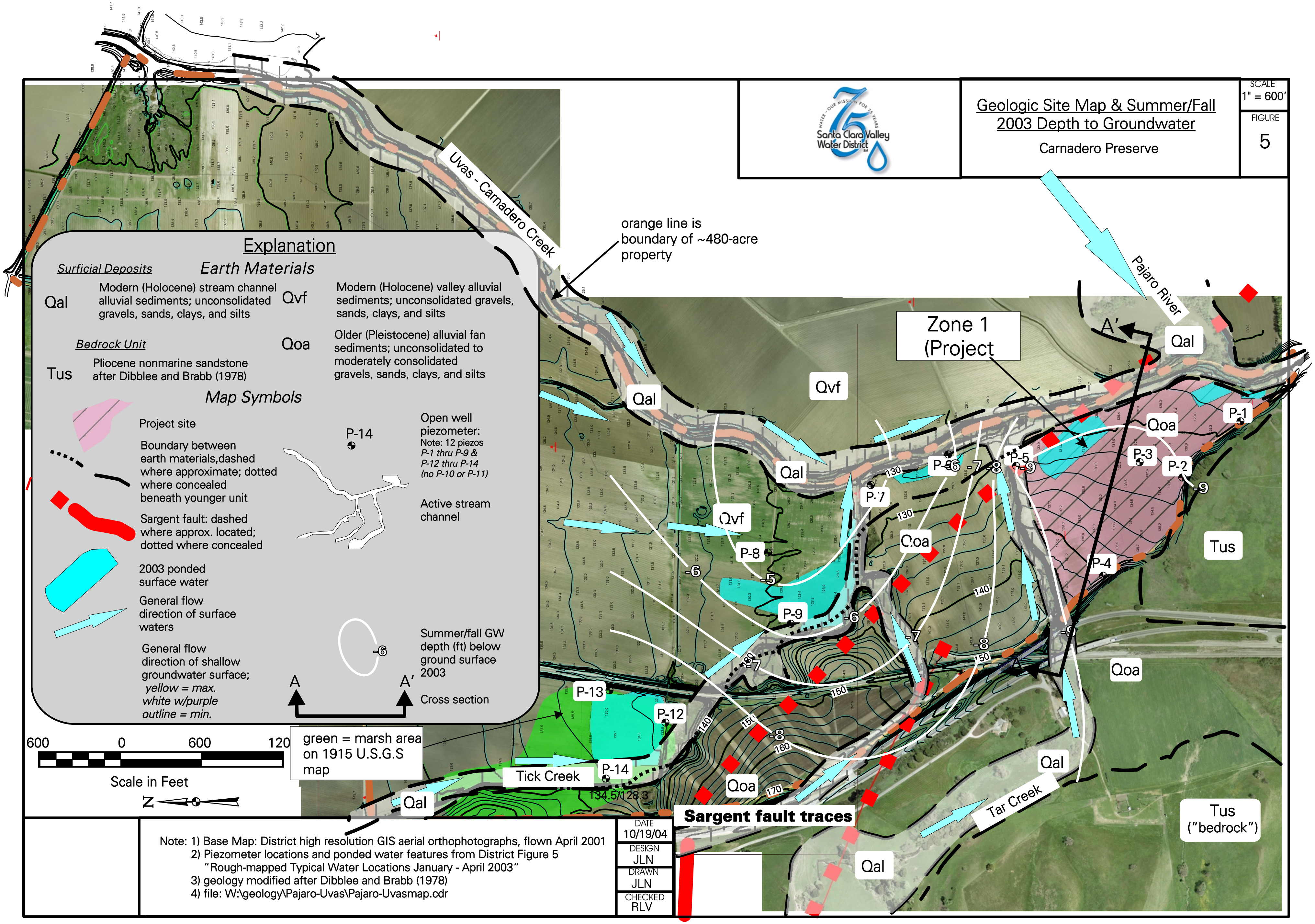
Santa Clara Valley Water District

Geologic Site Map & Summer/Fall 2003 Depth to Groundwater

Carnadero Preserve

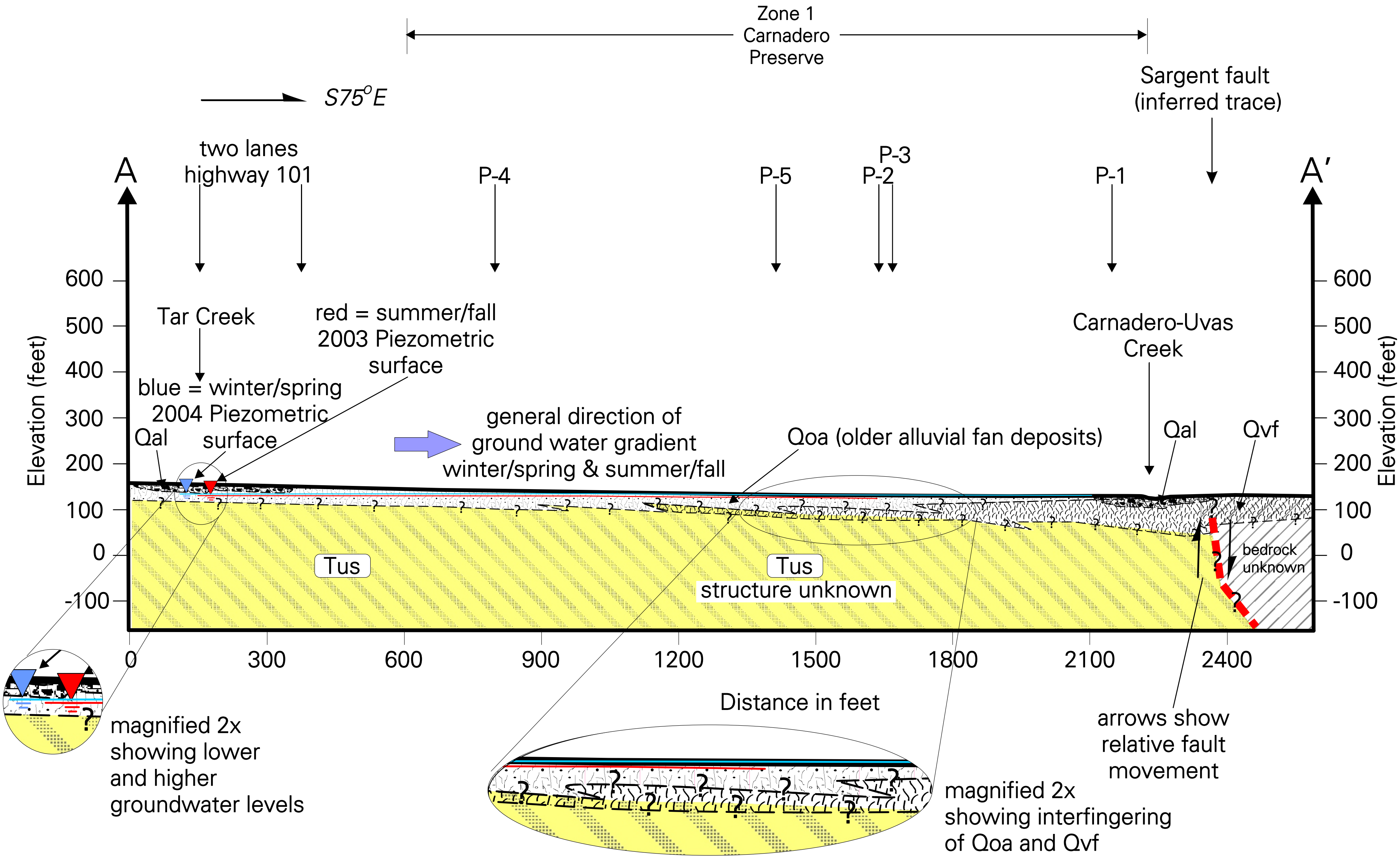
SCALE 1" = 600'

FIGURE 5


Explanation
Earth Materials
Surficial Deposits
Qal
Modern (Holocene) stream channel alluvial sediments; unconsolidated gravels, sands, clays, and silts
Qvf
Modern (Holocene) valley alluvial sediments; unconsolidated gravels, sands, clays, and silts
Bedrock Unit
Qoa
Older (Pleistocene) alluvial fan sediments; unconsolidated to moderately consolidated gravels, sands, clays, and silts
Tus
Pliocene nonmarine sandstone after Dibblee and Brabb (1978)
Map Symbols
Project site
Boundary between earth materials,dashed where approximate; dotted where concealed beneath younger unit
Sargent fault: dashed where approx. located; dotted where concealed
2003 ponded surface water
General flow direction of surface waters
General flow direction of shallow groundwater surface; yellow = max. white w/purple outline = min.
P-14
Open well piezometer: Note: 12 piezos P-1 thru P-9 & P-12 thru P-14 (no P-10 or P-11)
Active stream channel
-6
Summer/fall GW depth (ft) below ground surface 2003
A
A'
Cross section
600
0
600
120
Scale in Feet
N
green = marsh area on 1915 U.S.G.S map
orange line is boundary of ~480-acre property
Uvas - Carnadero Creek
Pajaro River
Zone 1 (Project
Tar Creek
Tick Creek
Sargent fault traces
Tus ("bedrock")
Tus
Qal
Qvf
Qoa
P-1
P-2
P-3
P-4
P-5
P-6
P-7
P-8
P-9
P-12
P-13
P-14
A'
-5
-6
-7
-8
-9
130
140
150
160
170
134.5/128.3

DATE	10/19/04
DESIGN	JLN
DRAWN	JLN
CHECKED	RLV

Note: 1) Base Map: District high resolution GIS aerial orthophotographs, flown April 2001
2) Piezometer locations and ponded water features from District Figure 5 "Rough-mapped Typical Water Locations January - April 2003"
3) geology modified after Dibblee and Brabb (1978)
4) file: W:\geology\Pajaro-Uvas\Pajaro-Uvasmap.cdr



Note: for location of section and explanation see Figures 2 through 5

DATE 12/8/04		**Geologic Cross Section**
DESIGN JLN		Carnadero Preserve
DRAWN JLN		SCALE 1″= 300′
CHECKED RLV		FIGURE 6